REPORT OF SURVEY CONDUCTED AT

STRYKER HOWMEDICA OSTEONICS
ALLENDALE, NJ

AUGUST 2000

Best Manufacturing Practices

1998 Award Winner

INNOVATIONS IN AMERICAN GOVERNMENT

BEST MANUFACTURING PRACTICES CENTER OF EXCELLENCE
College Park, Maryland
www.bmpcoe.org

Foreword

This report was produced by the Office of Naval Research's Best Manufacturing Practices (BMP) Program, a unique industry and government cooperative technology transfer effort that improves the competitiveness of America's industrial base both here and abroad. Our main goal at BMP is to increase the quality, reliability, and maintainability of goods produced by American firms. The primary objective toward this goal is simple: to identify best practices, document them, and then encourage industry and government to share information about them.

The BMP Program set out in 1985 to help businesses by identifying, researching, and promoting exceptional manufacturing practices, methods, and procedures in design, test, production, facilities, logistics, and management – all areas which are highlighted in the Department of Defense's 4245.7-M, *Transition from Development to Production* manual. By fostering the sharing of information across industry lines, BMP has become a resource in helping companies identify their weak areas and examine how other companies have improved similar situations. This sharing of ideas allows companies to learn from others' attempts and to avoid costly and time-consuming duplication.

BMP identifies and documents best practices by conducting in-depth, voluntary surveys such as this one at Stryker Howmedica Osteonics, Allendale, New Jersey conducted during the week of August 14, 2000. Teams of BMP experts work hand-in-hand on-site with the company to examine existing practices, uncover best practices, and identify areas for even better practices.

The final survey report, which details the findings, is distributed electronically and in hard copy to thousands of representatives from industry, government, and academia throughout the U.S. and Canada – *so the knowledge can be shared*. BMP also distributes this information through several interactive services which include CD-ROMs and a World Wide Web Home Page located on the Internet at http://www.bmpcoe.org. The actual exchange of detailed data is between companies at their discretion.

Stryker Howmedica Osteonics is an innovative leader in orthopaedics, providing creative engineering solutions to the most critical clinical problems. Its success has been built on the commitment, dedication, and focus of its talented team of employees. In addition, the company was named as one of America's Best Plants by *IndustryWeek* in 1998. Among the best examples were Stryker Howmedica Osteonics' accomplishments in team based cell manufacturing; skill based pay program; demand pull planning system; and continuing medical education.

The BMP Program is committed to strengthening the U.S. industrial base. Survey findings in reports such as this one on Stryker Howmedica Osteonics expand BMP's contribution toward its goal of a stronger, more competitive, globally-minded, and environmentally-conscious American industrial program.

I encourage your participation and use of this unique resource.

Anne Marie T. SuPrise

Anne Marie T. SuPrise, Ph.D.
Acting Director, Best Manufacturing Practices

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Section 1

Report Summary

Background

Stryker Howmedica Osteonics began as three independent companies, each with a rich heritage of contributions to the medical industry:

- In 1928, Dr. Homer Stryker was a practicing orthopaedic surgeon in Kalamazoo, Michigan. Dissatisfied with the medical products available at the time, Dr. Stryker began designing his own devices to meet his patients' needs. His inventions (e.g., Walking Heel, Turning Frame, Cast Cutter) laid the groundwork for the Orthopaedic Frame Company, which was incorporated in 1946 with a $20,000 investment by Dr. Stryker. In 1964, the company officially changed its name to the Stryker Corporation. Over the years, the company manufactured many innovative products such as the Cir-O-Lectric bed; the world's first hydraulic-lift stretcher; the first medical pulsed irrigation system; the first soakable solid-state medical video camera; and battery-powered instruments for reconstructive surgery. Today, the company is a strong global competitor in the worldwide medical market. With its corporate headquarters in Kalamazoo, Michigan, Stryker is organized into five domestic divisions (Biotech, Medical, Instruments, Endoscopy, and Howmedica Osteonics) and achieved $2.1 billion in sales in 1999.
- The forerunner of Howmedica began in 1926 with the introduction of Vitallium® by Drs. Reiner Erdle and Charles Prange who founded Austenal Laboratories. Vitallium® was originally designed as a new metal alloy for dental castings, but its reliability and effectiveness led to its use in manufacturing orthopaedic implant devices. Over the next 50 years, Austenal Laboratories underwent numerous changes: acquired by Howe Sound Company in 1958; renamed Howmet Corporation in 1965; spunoff from parent firm as Howmedica Inc. in 1968; and acquired by Pfizer Inc. in 1972. The constant factor during that time period was the company's leadership in innovative firsts including the Neer Vitallium® alloy shoulder; CAD technologies for designing orthopaedic implants; FDA-approved bone cement; non-hinged total knee systems; and porous-coating for biological fixation. Howmedica was acquired by the Stryker Corporation in 1998.
- Osteonics Corporation was founded in 1978 by two ex-Howmedica engineers and acquired by the Stryker Corporation in 1979. The company developed a reputation for creating revolutionary orthopaedic implant design concepts, which have become industry standards. Milestones include the Universal Head Replacement for the bipolar hip market; Normalizations concept; Osteo Trauma products; and material and wear reduction technology. In addition, Osteonics was the first to receive FDA-acceptance to market hydroxylapatite-coated products for cementless applications.

Stryker Howmedica Osteonics specializes in orthopaedic implant products, bringing together the market-leading products from each former component. In 1998, the company was named as one of America's Best Plants by *IndustryWeek*. Located in Allendale, New Jersey, Howmedica Osteonics employs 700 personnel. The company's success has been built on the commitment, dedication, and focus of its talented team of employees. The challenges they face in the changing healthcare marketplace require an organizational commitment to continuous improvement by adapting its skills and resources to meet customer needs. Among the best practices documented were Howmedica Osteonics' team based cell manufacturing; skill based pay program; demand pull planning system; and continuing medical education.

Howmedica Osteonics helped make joint replacement surgery one of today's most beneficial medical procedures,beginning in the early 1980s with its hip implant system. Now, joint replacement surgery enables more than 400,000 people in the United States to regain the mobility which they had lost to arthritis or trauma. Among those with a Howmedica Osteonics replacement hip are legendary Pro Golfer Jack Nicklaus and Former First Lady Barbara Bush. Howmedica Osteonics is an innovative leader in orthopaedics, providing creative engineering solutions to the most critical clinical problems. The BMP survey team considers the practices in this report to be among the best in industry and government.

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Section 2

Best Practices

Production

Investment Casting Process

The Investment Casting Process operates as a transfer method to manufacture investment cast parts. All of the process steps must be strictly controlled. An investment casting team studied and streamlined all of the transfer steps (e.g., developing the design, using wax injection to create the pattern, pouring the liquid metal into the ceramic mold), enabling Howmedica Osteonics to significantly reduce its lead times.

In 1992, Howmedica Osteonics developed a cellular environment throughout its facility so that team-focus approaches could be directed at specific process improvements. Also that year, the company began concerted efforts to improve the quality and cost of its Investment Casting Process, a core part of its business since 1980. An investment casting team was set up as a support cell to streamline the transfer method used to manufacture parts. Previously, the company incurred high processing costs and a large inventory due to its 11% rejection rate of parts and excessive lead times.

The Investment Casting Process operates as a transfer method to manufacture investment cast parts. Among the steps are developing the design, producing the wax injection mold, using wax injection to create the pattern, assembling the pattern into a tree arrangement, adding the ceramic slurry to create the mold shell, removing the wax from the mold, preheating the mold, and pouring the liquid metal into the ceramic mold. All of the process steps must be strictly controlled. The investment casting team studied and improved all of the transfer steps. As a result, Howmedica Osteonics now produces ceramic shells from a rarely used alumina silicate ceramic material. The shelling technique involves dipping the entire pattern assembly into the ceramic slurry, draining it, and coating it with fine ceramic sand. After drying, this process is continuously repeated using progressively coarser grades of ceramic material until a self-supporting shell is formed. The various transfer steps allow the dimensional and metallurgical variations to improve through shrinkage control, mold preparation, ceramic composition of the mold, and metal casting temperatures.

Since streamlining the Investment Casting Process, Howmedica Osteonics has significantly reduced its lead times (Figure 2-1). The rejection rate of parts has also decreased from 11.4% in 1992 to 2.72% in 1999. These rates were reduced by implementing a new shell formula, revising cast techniques, establishing new setups, and refining process controls.

Product Recognition Technology Project

Many orthopaedic parts within a family are almost identical in size and shape. To resolve misidentification during batch runs, Howmedica Osteonics developed the Product Recognition Technology Project which consists of three elements: the Product Verification System; the 2-D Data Matrix Marking System; and the Elimination of Manual Data Entry. Each element's goal is to reduce the number of product identity errors.

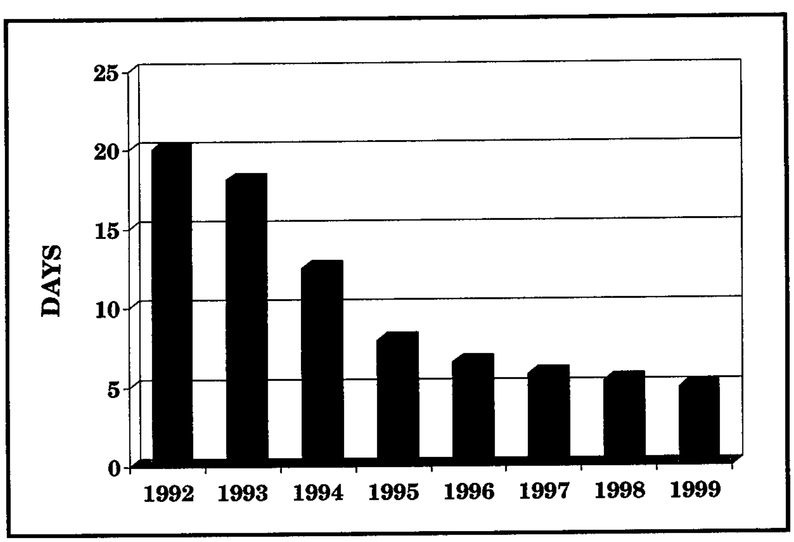

Figure 2-1. Investment Casting Lead Time Analysis

Howmedica Osteonics has adopted a cell-oriented manufacturing philosophy in which a semi-autonomous group is responsible for a specific part family. Many of the parts within a family are almost identical in size and shape. Because a typical product mix consists of many small batches and numerous manual operations, a great potential exists for product identity errors. To resolve this situation, the company developed the Product Recognition Technology Project which consists of three elements: the Product Verification System; the 2-D Data Matrix Marking System; and the Elimination of Manual Data Entry. Each element's goal is to reduce the number of product identity errors.

- The Product Verification System is a compact, computer-controlled package consisting of a weigh scale and a 3-D, multicamera-based vision system. The operator begins the process by scanning the work order router sheet that accompanies each part. The computer then retrieves product dimensional and fixture/placement information on the part from a Microsoft Access database. Next, the operator positions the part on the weigh scale based on prompts from the computer, and presses the verify button on the touch-screen monitor. The 3-D vision system verifies that the part matches the information on the router sheet by comparing key features from the part's image with corresponding features of the image stored in the database. The computer then displays a Go/No Go message and keeps track of the number of parts which have been measured. Although this method works for part identification, the measurement accuracy is generally insufficient to replace a separate dimensional inspection operation. As technology improves, Howmedica Osteonics will re-examine this method for dimensional inspection. The Product Verification System is easy to use, has gained operator acceptance, and has demonstrated its ability to catch errors prior to final packaging of the product.
- The 2-D Data Matrix Marking System uses a rectangular matrix of tiny squares to encode product information on parts more efficiently than standard barcodes. In addition, standard barcode information obtained from a part's router sheet can also be converted to the 2-D data matrix format, via software, to generate the machine-control code to produce the matrix. Up to 25 characters can be permanently encoded in a 1/8-inch-square matrix on the part's surface. Data matrix codes can be applied with a laser marker (the most robust method), machined on the part's surface, or cast directly into the part. The data matrix is applied early in the manufacturing process to minimize the possibility of part identity errors, and is read by handheld or fixed Charge-Coupled Device scanners. The data-encoding scheme relies on light and dark areas within the matrix. Therefore, a special LytePype™ attachment, tailored to the geometry of each part, must be used with the Charge-Coupled Device scanner to ensure appropriate lighting conditions. Once the data matrix is applied to the part, it can be used at any subsequent stage of manufacturing and possibly for field tracking in the future. Although this technology may eliminate the potential for part misidentification, several barriers must be overcome before it can gain plant-wide acceptance. These barriers include slightly increased lead times, the need for more robust scanning devices, determining an appropriate marking location for all part families, and identifying the earliest operation at which a code can be applied and still withstand all subsequent operations without damage.
- The Elimination of Manual Data Entry of router information addresses two potential part identification problems. First, the operator can inadvertently apply the incorrect part number and/or lot identification to a part during the laser marking process. This problem is being minimized by using a barcode scan from the shop floor router as the only input to mark the part number and lot identification on the product. Second, the operator can inadvertently machine a part of the wrong size or type by entering incorrect information at the machining center's Computer Numerical Control console. This problem is being minimized by using a barcode scan from the shop floor router as the only input to activate the required Computer Numerical Control program for the manufacture of the product from raw stock. The barcode reader is interfaced with the serial communications port (RS-232) of the machine tool controller as well as the PC that contains stored programs for entire part families. Scanned information is passed to the computer and parsed to generate an appropriate four-digit part number, which is used in a look-up table to retrieve the correct Computer Numerical Control program. Up to 16 different machine

tools can be controlled by a single PC. The process can also be used to pass statistical process control and shop floor control information from the controller back to the PC. The software also has the capability for data matrix encoding.

Howmedica Osteonics has implemented the three elements of the Product Recognition Technology Project in one or more manufacturing product cells, and will gradually be phasing them into other cells as the technology becomes more mature.

Robotic Plasma Spraying and Ceramic Powder Manufacturing

Hydroxylapatite is a hexagonal, calcium-phosphate mineral used to promote bone growth onto orthopaedic implants. Looking for a way to reduce inventory, decrease costs, and control the powder's material properties, Howmedica Osteonics decided to implement an in-house Ceramic Powder Manufacturing process to manufacture hydroxylapatite. A Robotic Plasma Spraying process is then used to coat the parts. This process involves loading the plasma gun with hydroxylapatite, and using a plasma flame to spray the partially melted powder onto the part.

Hydroxylapatite is a hexagonal, calcium-phosphate mineral used to promote bone growth onto orthopaedic implants. In the past, Howmedica Osteonics purchased hydroxylapatite from a vendor and used a multi-step robot/turntable machine process to apply the powder onto the parts. Looking for ways to reduce work-in-process inventory, decrease hydroxylapatite costs, and control the powder's material properties, the company decided to implement an in-house process to manufacture hydroxylapatite.

The Ceramic Powder Manufacturing of hydroxylapatite powder begins as a mixture of chemicals. The mixture is then analyzed by sintering a small amount from the batch. The material constituents are measured, and small amounts of the deficient ingredient(s) are added until the slurry has the correct hydroxylapatite chemistry. Ammonia is added to stabilize the mixture and impede further chemical reaction. The mixture is then spray dried to produce round particles of consistent size. After it is fed through an aerosol gun, the mixture travels in a hot cyclonic pattern to evaporate the water. Large and fine particles are also collected separately at the bottom of the system. The hydroxylapatite powder is then placed in saggers into large ovens, and sintered at approximately 2200°F for six hours to facilitate the growth of crystals. The powder densifies, removing small pores. The large and fine particles are then blended for homogeneity and sieved to ensure that 90% of the particles are less than 100 micrometers in size. Further testing is performed to ensure correct chemistry and purity, accurate density, and sufficient crystallinity. Prior to being coated, the orthopaedic implants are surface prepared, cleaned, loaded into a carousel application system, and preheated. Robotic Plasma Spraying is used to coat the parts. This process involves loading the plasma gun with hydroxylapatite powder, and using a plasma flame to spray the partially melted powder onto the part. The parts undergo a final cleaning and are inspected for mechanical integrity.

The in-house Ceramic Powder Manufacturing of hydroxylapatite provides Howmedica Osteonics with many cost savings and improved quality control. Among these benefits are:

- Controlled size and roundness of the particulate allows for consistent application through the plasma gun.
- Manufacturing costs for hydroxylapatite powder has been reduced by 306%.
- Carousel application system provides continuous gun operation, since parts are now preheated prior to spraying instead of being heated with the plasma flame.
- Coating capacity is increased from 200 parts per day to 300 parts per day by using the carousel system.
- Powder usage is reduced by 33% per implant.
- Process time is reduced from seven minutes per part to three minutes per part.
- Powder inventory costs are reduced from $117,000 to $7,200.
- Current annual cost savings for powder manufacturing is $860,000.
- Current annual cost savings of the coating system is $560,000.
- Total resultant cost savings equals $1.4 million per year.
- Product lead times and inventories have significantly been reduced.

Streamlining Manufacturing

Howmedica Osteonics continues to streamline its manufacturing operations by implementing new technology. Operations which have undergone these improvements include the manufacture of cobalt-chrome stem caps, custom knee implants, femoral components, titanium hip stems, hip instruments, endo components, bone screws, and tibia inserts to name a few. As a result of process improvements, the company has achieved better process control; reduced manufacturing costs and lead times; increased quality and capacity; improved its partnerships with vendors; and significantly increased productivity.

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- Previously, the manufacture of cobalt-chrome stem caps used in hip implants required two turning operations as well as grinding and polishing. By purchasing a twin-spindle, horizontal machining center with a unique offset secondary spindle, the company was able to change to a single setup that performed the turning and grinding simultaneously. As a result, the independent grinding operation was eliminated and the polishing operation became automated. The overall cycle time was also reduced from 50 minutes per part to 10 minutes per part.
- Previously, the manufacture of custom knee implants was a time-consuming process that required many days or weeks, depending on the order. The company streamlined this process by combining ProEngineer's solid-modeling capabilities with Stratasys' rapid prototyping capabilities to produce a wax insert. Starting with a ProEngineer solid model, minor modifications are performed to tailor the model to the non-standard dimensions of the custom component. The Stratasys operation begins with 20 minutes of preparation time, and then runs unattended for six to 14 hours to produce the wax insert. The insert is used to produce a mold for investment casting of the knee implant. Afterwards, traditional manufacturing processes are used.

Similar impressive improvements were also implemented in the manufacture of femoral components, titanium hip stems, hip instruments, endo components, bone screws, and tibia inserts. In all cases, continuous manufacturing process improvement and streamlining have led to a 10% reduction in the cost-of-goods-sold for eight consecutive years at Howmedica Osteonics. All process improvements began with the goal of reducing lead times, which resulted in the improvement of other production process metrics.

Management

Continuing Medical Education

Continuing education is an FDA-mandated requirement for surgeons to maintain their licenses to practice. Although specific requirements vary by state, 50 credit hours of training must be completed every year. Howmedica Osteonics developed and maintains Continuing Medical Education, a top-quality training program on orthopaedic implant products. The company's philosophy is to provide 100% technical training in the use of its equipment.

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Howmedica Osteonics supports medical education programs through an accredited educational sponsor (e.g., university, hospital, clinic). Continuing Medical Education uses a balanced approach which focuses on educational content; expert speakers; scientific and clinical aspects; and new technologies. The educational content employs outside resources (e.g., non-customers) as an interaction key and provides the sharing of information through

speakers, videos, abstracts, and hands-on experience. The scientific aspect centers on pre-clinical and clinical research as well as scientific studies to support product concepts, design basics, and techniques. Clinical topics involve peer-reviewed literature comparisons to determine what worked and why. New technology training is not product-specific. Initial findings are also analyzed to determine what worked and why, as well as provide foresight on upcoming technologies. One of the most value-added methodologies employs surgeons to train surgeons.

Through its Continuing Medical Education training program, Howmedica Osteonics provides unique training and education. The program offers high-level academic speakers, technical training, analysis of new technology, and hands-on experience. The company's logistics planning results in flawless care of details and attention on the customer. The success of Continuing Medical Education is evident by the retention of existing customers, the increase in program participation, positive feedback from customers, and a 100% accomplishment of set objectives.

Demand Pull Planning System

In 1992, Howmedica Osteonics developed the Demand Pull Planning System which is based on the philosophy of placing just enough material on the production floor to satisfy the rate of customer demand. The company developed its new philosophy by exploring concepts from other reliable systems (e.g., lean manufacturing, just-in-time, KanBan, finite loading, levelized scheduling, one-piece flow), and blending the best processes from these systems to best fit its situation.

In the past, Howmedica Osteonics used a traditional push system which employed Material Resource Planning techniques to control and track everything. Push systems tend to place an overabundance of parts on the factory floor, which leads to large volumes of work in process, excessive inventories, significant overhead for tracking parts, large queue areas consuming valuable floor space, and high cycle times. This approach also typically results in higher costs and low customer service. In 1992, Howmedica Osteonics developed the Demand Pull Planning System which is based on the philosophy of placing just enough material on the production floor to satisfy the rate of customer demand.

Howmedica Osteonics developed its new philosophy by exploring concepts from other reliable systems such as lean manufacturing, just-in-time, KanBan, finite loading, levelized scheduling, and one-piece flow. By blending the best processes from these systems to best fit its situation, the company developed and implemented its current system. The Demand Pull Planning System reacts to new work orders, that are reported by the Sales Team and tallied each evening, by producing a simple, daily spreadsheet within minutes. The Production Planner then makes decisions on the day's production for each manufacturing cell, based on the spreadsheet, and issues the work orders. Each cell calls up the necessary material and produces only the assigned orders of the day. The Demand Pull Planning System eliminates non-value-added tasks and reduces work in process, cycle times, and operating expenses. In addition, this system keeps parts moving throughout the manufacturing cell before new parts are issued. Problems are no longer masked by large volumes of work in process, and root cause of problems can be immediately identified and corrected to reduce scrap and improve reliability.

Howmedica Osteonics has successfully implemented the Demand Pull Planning System in all of its manufacturing cells that produce orthopaedic hip and knee implants. The result is a magnitude of cost savings and benefits, including:

- Decrease in lead times for Type A hip implants from 62 to 16 days.
- Decrease in lead times for Types B, C, and D hip implants from 33 to two days.
- Decrease in lead times for Type A knee implants from 83 to 15 days.
- Decrease in lead times for Type B knee implants from 46 to nine days.
- Cost reduction of Past Due Orders from over $5 million in 1992 to less than $0.5 million in 2000.
- Cost reduction of Total In-house Inventory from $31 million in 1992 to just under $17 million in 1997.
- Availability of premium floor space for production growth.

Five Pillars and Visual Controls Program

The Five Pillars and Visual Controls Program is a discipline used to organize and maintain the cleanliness of the workplace by using visual con-

trols. The concept of the program flows down from the Team Leaders to the Team Members within each manufacturing cell. Team Members are instructed to follow the basic philosophy, but are given flexibility to best fit the concept to their own cells. Color coding is the only control that is held standard.

The Five Pillars and Visual Controls Program is a discipline used to organize and maintain the cleanliness of the workplace by using visual controls. Among the drivers that led to the adoption of this program at Howmedica Osteonics were product quality and process control; employee safety; limited floor space; customer impressions; and employee satisfaction.

The Five Pillars (also known as the five S's) provide understanding and discipline:

- Sort (organization) distinguishes between what is and is not needed.
- Straighten (orderliness) identifies a place for everything and puts everything in its place.
- Sweep (cleanliness) focuses on cleaning and looks for ways to keep it clean.
- Schedule (adherence) maintains guidelines and monitors adherence.
- Sustain (self-discipline) advocates practice and repeatability until it becomes habitual.

The Visual Controls provide a powerful mechanism for executing the Five Pillars. Color tape is used to identify the boundaries of manufacturing cells and the locations of equipment, materials, and supplies. Labels are used to identify the contents of cabinets, containers, and folders. Tool sets are also organized within drawers and on workbenches by using shadow boxes, partitions, and compartments. Throughout the workplace, charts and graphics illustrate each cell's work content and performance. The color codes used by Howmedica Osteonics include:

- Red for hazardous material and waste.
- Yellow for aisles, personal protective equipment modified areas, and non-production areas.
- Blue for supplies, tools, and indirect material.
- Green for raw and work-in-process material.
- Green/White for shipping and receiving.
- Red/White for trash, scrap, reject, and hold items.

The concept of the program flows down from the Team Leaders to the Team Members within each manufacturing cell. Team Members are instructed to follow the basic philosophy, but are given flexibility to best fit the concept to their own cells. Color coding is the only control that is held standard. Each cell employs slight differences in its application, but still follows the basic concept. In addition, Team Members are continually improving the program by developing innovative ideas and exchanging information with other cells. Sustainment is maintained by auditing the cells every 40 days and generating a scorecard to chart their progress. Although somewhat subjective, the scorecard helps highlight deficiencies and identify areas for improvement.

Key to the implementation and buy-in of the Five Pillars and Visual Controls Program is strong backing by top management. As demonstrated at Howmedica Osteonics, the program can be implemented in a very short time and reap immediate benefits.

Sales Training

To maintain a strong sales personnel base, Howmedica Osteonics developed an innovative and effective Sales Training Program designed to enable sales representatives to learn quickly and retain information. Key to the program is the focus on student participation. As a result, the Sales Team is not only affluent in communication and business skills, but also knowledgeable in orthopaedic products, process technology, and medical terminology associated with orthopaedic surgery techniques.

As with any business, aggressive marketing and competent sales personnel enable a company to develop new clientele and maintain present ones. In the highly competitive industry of orthopaedic implants, however, technological advancements in material and medical sciences flood the industry daily. To maintain a strong sales personnel base, Howmedica Osteonics developed an innovative and effective Sales Training Program designed to enable sales representatives to learn quickly and retain information. As a result, the Sales Team is not only affluent in communication and business skills, but also knowledgeable in orthopaedic products, process technology, and medical terminology associated with orthopaedic surgery techniques.

The Sales Training Program does not employ a traditional classroom environment. Instead, the program applies Participant-Centered Training Techniques which were largely modeled from two

literature sources: *Accelerated Learning* by Dave Maier and *Creative Learning Techniques* by Bob Pike. These resources, plus ideas from the Sales Team, enabled Howmedica Osteonics to develop the techniques for its Sales Training Program. Key to the program is the focus on student participation. The course provides students with knowledge, information, facts, and data designed for immediate implementation. A supportive environment is also created for exploration, struggle, and discovery so that insights are gained through the student's own involvement. Each segment of the program provides an equal distribution of time for instructional content, student activity, and review. In addition, each course is orchestrated by the trainer to optimize student participation in the learning process.

All courses in the Sales Training Program follow the same design. Howmedica Osteonics provides this training to its new as well as existing sales representatives. Courses range in length from two days to two weeks. Classes average around 16 to 20 students with a maximum of 25 attendees. Classroom attention is very high and a course-content retention of 90% has been attained using this Sales Training Program.

Skill Based Pay Program

On January 1, 1994, Howmedica Osteonics implemented a hybrid Skill Based Pay Program. The goal was to motivate the Team Members within a cellular-focused structure through this compensation program. Goals are set across as well as within the manufacturing cells. Among these goals are: fulfilling the Skill Based Pay core blocks within 12 months of being hired and, each year, completing at least two new skill blocks (as outlined in a skills path matrix) to be eligible for the yearly raise.

Previously, Howmedica Osteonics compensated its employees based on individual efforts and levels of performance. In 1992, the company realized its salary administration and bonus plan did not support the goals of the newly established, team-based cellular environment. A major transformation ensued and Howmedica Osteonics initiated a hybrid Skill Based Pay Program on January 1, 1994. The goal was to motivate the Team Members within a cellular-focused structure through this compensation program.

A team-oriented work structure evolved through the creation of an Operations Steering Team and 13 Operations Cells. All employee titles were reduced to just three: Steering Team Member, Team Leader, and Team Member. Led by a Team Leader, each cell focused on either a manufacturing process, product, or support function. Skill Based Pay objectives were established to achieve common goals across the cells. These goals are set by the Operations Steering Team on an annual basis depending on customer and business needs. Skill Based Pay core blocks were also established as a set of minimal skills which employees needed to work in Operations and as prerequisites to learning other skill blocks. The core blocks consist of basic mathematics, blueprint reading, measuring instruments, safety, team building, work simplification, and good manufacturing practices. A condition of employment at Howmedica Osteonics is the completion of the Skill Based Pay core blocks within 12 months of being hired.

Employees must also complete at least one skill block of training every six months until they have completed all the blocks as outlined in a skills path matrix. The skills path matrix is a living document that identifies the skills needed to perform work in an Operations Cell, and establishes career roles on each team. Each Team Member must be block-certified for competency. Completion of the required training is the responsibility of the Team Member and, as an incentive, impacts next year's merit increase and this year's bonus. Howmedica Osteonics provides training during or after work hours depending on whether it is a core skill or a new training activity. The training has built-in expectations so employees can devote personal time to skill acquisition which, if not applied, affects their own development as well as their cell's team members. Training Requirements Forms also are provided to assist Team Members in preparing for skill block testing, certification, and documentation. Measurements allow for periodic assessment of various team performance-to-operation goals, and each skill path is evaluated based on its primary duties. Operations uses two classifications as required by Federal law: exempt and non-exempt. Based on performance pay purposes, the Human Resources Team determines the classification of each skill path.

The results of the Skill Based Pay Program are evident in the quality, service levels, and cost-reduction efforts at Howmedica Osteonics. The successful completion of core/skill blocks by employees has resulted in a 50% reduction in scrap material. By using the Skill Based Pay Program, the

company has also produced cross-functional employees, empowered team members, and holds teams accountable for their work. Additionally, Howmedica Osteonics has noted a higher level of engagement in workplace activities and sees a more committed workforce.

Strategic Mission and Values Statement

With the 1998 merger of Stryker Osteonics and Howmedica, the leaders of the company wanted to bring the employees together with a clearly understood mission, not just a poster on the wall. In addition, the company wanted to gain customer loyalty by exceeding their expectations and establishing a unique bond with them that transcends everyday business interactions. As a result, the company developed its Strategic Mission and Values Statement. An ongoing company-wide campaign keeps the mission, objectives, and values message fresh and highly visible to employees.

With the 1998 merger of Stryker Osteonics and Howmedica, the leaders of the company felt they were truly poised to lead the marketplace. However, they also realized this goal needed more than just sales and profits to succeed. It would require the efforts and talents of every employee working toward a common mission and values. Howmedica Osteonics wanted to bring the employees together with a clearly understood mission, not just a poster on the wall. In addition, the company wanted to gain customer loyalty by exceeding their expectations and establishing a unique bond with them that transcends everyday business interactions. The challenge was to get the message out and engage all employees. As a result, the company developed its Strategic Mission and Values Statement: To be the recognized leader in global orthopaedics by building intense customer loyalty to Howmedica Osteonics.

With help from the Human Resources and the Marketing Communication Teams, Howmedica Osteonics launched its slogan, "Building Intense Customer Loyalty," at a July 1999 meeting. Here, the company's President introduced the strategic mission and values, and challenged Managers and Team Leaders to bring the message back to their respective teams. Next, seven leaders representing cross-functional teams described what the values meant to them personally as well as what they meant to the teams and the company. The momentum continued throughout the year with various activities, including using the new slogan as the theme for the Howmedica Osteonics National Sales Meeting in January 2000. At this event, the President and Vice President of Sales introduced the company's strategic mission, vision, and values to the assembled selling group. Since the initial kick-off, the Team Leaders have communicated the company's strategic mission and values to every employee. Team Leaders have discussed the impact that each employee has on the success of the corporate mission, as well as provided clear directions as to how they can specifically contribute to the company's Corporate Objectives. An ongoing company-wide campaign to maintain the excitement and commitment toward the mission includes employee quarterly meetings held by the President and staff at the Allendale and Rutherford, New Jersey plants. Additionally, an extensive communication package consisting of keepsake gifts, screen savers, signage, videos, and customer testimonials are made available to employees and sales personnel. Howmedica Osteonics keeps the mission, objectives, and values message fresh and highly visible to its employees through ongoing newsletters, voice mails, and the highlighting of behavior simpatico with the company's values and mission.

Translating the success of communicating and achieving Howmedica Osteonics' Strategic Mission and Values Statement is best left to the bottom line of sales and growth, and the measure of employee engagement in the process. The company reports it is achieving its annual profit growth rate of 20% and is on track to achieve its stretch goal of $1 billion by 2004. The internal Gallup Q-12 Survey also indicates that employee attitude is scoring high in the following categories: mission correlating to their job, understanding of expectations, commitment to doing quality work, and having the appropriate materials/equipment to perform their work. Overall employee satisfaction is in the 63rd percentile of all companies in Gallup's extensive database.

Team Based Cell Manufacturing

In 1992, Howmedica Osteonics radically changed its approach by implementing Team Based Cellular Manufacturing, a cellular environment that focused on product rather than process. In cellular manufacturing, product focus means customer focus. As a result, the company has developed a flatter, leaner organization through management streamlining, employee empowerment, accountability, and customer focus.

Howmedica Osteonics previously used traditional manufacturing methods which eventually lead to poor service levels, long lead times, high inventory and back orders, high product costs, and multiple levels of management. Poor communication also existed between functional departments. In 1992, Howmedica Osteonics radically changed its approach by implementing Team Based Cellular Manufacturing, a cellular environment that focused on product rather than process.

In cellular manufacturing, product focus means customer focus. The cellular approach at Howmedica Osteonics is key to Operations' strategy, and includes management concepts and techniques common to world-class manufacturing. A cellular layout of the plant allows each cell to be managed as a single business. Two levels of management co-exist within each cell which promotes communication among Team Leaders, Team Members, and vendors. Team Members within a cell are equally empowered to ensure the cell, as a whole, will achieve its operational goals. Accountability applies to everyone and enables Howmedica Osteonics to achieve higher operational performance. Performance measurements are reported daily, weekly, and monthly using a standard set of key business driver measurements which are linked to Operations' goals. Key measurements include quality, service level, cost, lead times, inventory dollars, and turnaround time. Total quality is built into each product via multi-skilled workers, preventive maintenance (skill blocks), and continuous improvement. High performing work teams progress through six stages of development: (1) assessment of organization and business environment, (2) introduction of cell concept and product-focused work teams, (3) education and training, (4) introduction to work simplification, (5) performance measurements, and (6) implementation of a Skill Based Pay Program.

Since implementing Team Based Cell Manufacturing, Howmedica Osteonics achieved product cost reductions by more than 50% between 1991 and 2000. In-house inventories have also been reduced by 50% and are more in-line with customer demands. In 1993, the ratio of average units per square foot to average units per Operations employee were 5.70:1,109. By 1998, this ratio was 11.66:1,757. The cells are achieving 99% of their goals with an increase in service levels of 10% to 15% in five years. Operational improvements begin almost immediately after a performance measurement is implemented due to a higher cell team understanding of set goals and the challenges to reach those goals. Howmedica Osteonics has developed a flatter, leaner organization through management streamlining, employee empowerment, accountability, and customer focus. This approach goes beyond setting up a few customer product-focused work teams. Instead, the entire manufacturing organization consists of product-support cells.

Section 3
Information

Design

Materials Science Laboratory and Computer Aided Engineering

Howmedica Osteonics' Technical Services Group, Materials Science Laboratory is responsible for implant device evaluations such as risk analysis; verification of safety and functionality; specification, characterization, and testing of materials; establishment of device performance criteria; verification of performance criteria through fatigue and wear testing; and technical advisory support. The group also routinely uses computer aided engineering, computer aided design, finite element analysis, and mechanical systems simulation. For evaluating devices, these tools have considerably shortened the design-realization cycle for implant devices.

Howmedica Osteonics' Technical Services Group, Materials Science Laboratory in Rutherford, New Jersey is part of the Advanced Technology organization. The group is responsible for implant device evaluations such as risk analysis; verification of safety and functionality; specification, characterization, and testing of materials; establishment of device performance criteria; verification of performance criteria through fatigue and wear testing; and technical advisory support. The facility houses possibly the world's largest collection of instruments for tribological testing of medical implants and related devices. In addition, there are numerous specialized mechanical test systems including 34 uniaxial, four multi-axial, five electromechanical, and nine high-cycle fatigue test systems for tensile, flexure and fatigue tests. Many of these systems were designed in-house to meet special test needs.

The Technical Services Group routinely uses Computer Aided Engineering as a basic and applied research tool. Computer Aided Engineering tools include computer aided design, finite element analysis, and mechanical systems simulation. For evaluating devices, these tools have considerably shortened the design-realization cycle for implant devices. Prior to Computer Aided Engineering tools, components were defined as continuous surfaces of complex geometry and described by complex differential equations that were not readily solvable on available computer equipment. Computer modeling was impractical and the design cycle consisted of an iterative process of make-it-and-break-it. Once a conceptual component was designed, a prototype was built and tested to failure. The process was repeated until an acceptable product was developed. The request for regulatory approval was not made until sufficient laboratory test data had been accumulated on production parts to demonstrate product performance. The entire design cycle was time-consuming and expensive.

Computer Aided Engineering tools have also been used to reduce product development cycle times and costs, and improve product quality and performance. Mechanical design and testing now employs a single-pass process rather than an iterative process. The computer quickly generates and tests virtual prototypes repeatedly until a usable design is achieved. The virtual prototype can also be enhanced and optimized prior to undergoing physical testing. In some instances, finite element analysis and mechanical systems simulation results can be submitted, instead of laboratory test data, during the regulatory approval process.

Rapid Prototyping

Howmedica Osteonics has implemented a Rapid Prototyping System integrated with ProEngineer solid modeling software to enhance the development of new products. This investment provides flexibility to produce durable prototype parts within hours, allows design criteria to be quickly determined, and promotes early client buy-in at the concept stage.

Howmedica Osteonics has implemented a Rapid Prototyping System integrated with solid modeling software to enhance the development of new products. Previous methods of producing design prototypes included machining parts within one to three days, producing soft-metal tooling within three to five days, and outsourcing for stereolithography parts. Howmedica Osteonics invested in a Rapid Prototyping System to obtain flexibility in-house to

produce durable prototype parts within hours. The system was implemented so that design criteria could be quickly determined and client buy-in could begin early at the concept stage.

Howmedica Osteonics utilizes ProEngineer to create solid models that can be transferred to a rapid prototyping machine. Solid-model files are transferred as STL files into a Stratasys FDM 2000 machine. The Stratasys machine produces ABS plastic or investment cast wax prototypes within hours. Initially, engineers meet with surgeons and discuss tool and product needs. Sketches are then transferred into ProEngineer as solid models. Files are input to the Stratasys machine and next-day prototypes are shown to the surgeons to further develop form-and-fit advancement.

The primary benefits of the Rapid Prototyping System are early client involvement and buy-in. The approach enables design criteria to be quickly narrowed down and expedited. The product development cycle is also shortened due to a decrease in design iterations. Prototypes are concurrently utilized for marketing purposes. Other applications of the solid-model files involve machining, tool design, inspection drawings, finite element analysis, product drawings, fixtures, gauges, x-ray templates, inspection overlays, and marketing materials. At Howmedica Osteonics, recent new product development occurred in nine months and product delivery was one month ahead of schedule, thereby generating $1 million per month in sales along with client confidence.

In the past, Stryker Osteonics and Howmedica administered their own employee feedback process (e.g., 50-question Max survey) to evaluate productivity, employee retention, profit, and customer satisfaction. After the 1998 merger, Howmedica Osteonics established new company core values to guide its individual and group efforts. In May 1999, the company implemented the Gallup Q12 Survey as a streamlined method for measuring employee job satisfaction and employee engagement. The survey consists of 12 questions and provides a vehicle for employees to communicate with management.

Howmedica Osteonics will be conducting the Q12 Survey on an annual basis. The questions target the employees' perspective on company expectations, training, upward mobility, and work environment. Employees answer the questions on a one-to-five scale from extremely dissatisfied to strongly satisfied. The results of the survey are tallied through the Gallup Organization, Independent Specialty Research Organization. Each question is assessed in four categories (productivity, employee retention, profit, and customer satisfaction) to identify areas of improvement for overall company growth and profit. The Gallup Path (Figure 3-1) shows the relational route from strengths through stock increase as influenced by the Q12 Survey. The survey results are tabulated on a Gallup scorecard which provides Howmedica Osteonics with a breakdown of the answers according to grand mean, overall

Management

Gallup Q12 Survey

After the 1998 merger, Howmedica Osteonics established new company core values to guide its individual and group efforts. In May 1999, the company implemented the Gallup Q12 Survey as a streamlined method for measuring employee job satisfaction and employee engagement. The survey consists of 12 questions and provides a vehicle for employees to communicate with management.

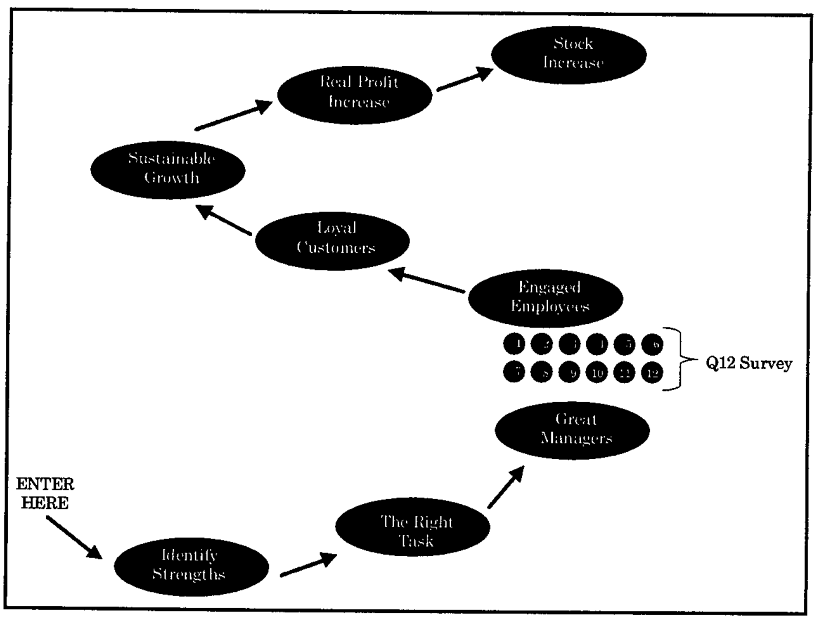


Figure 3-1. The Gallup Path

satisfaction, individual questions, and engagement hierarchy. The engagement hierarchy uses a pyramid arrangement to group the questions into Overall Growth, Teamwork, Management Support, and Basic Needs. Howmedica Osteonics uses training to discuss and explain the survey results to its managers who, in turn, educate their respective groups.

The results of the Q12 Survey can be used as an effective management tool to employ and retain qualified and loyal employees who are passionate about their work and contribution within the company. Individual job satisfaction has a direct influence on team performance and company goals. Based on the May 1999 results, 82% of the employees participated in the first survey. The results indicate an improvement in employee-management relationships, and an increase in efficiency and decrease in production time due to employee empowerment. Management highly encourages employee engagement in building a stronger workplace through team feedback.

Howmedica Osteonics has established a baseline with the initial Gallup Q12 Survey. As more data is gathered from future surveys, the company will be able to measure employee levels of satisfaction and correlation with goals (e.g., retention, profit). The company's goals are to create a healthy, productive, results-focused environment and achieve $1 billion in sales by 2004.

On-line Training

Howmedica Osteonics is in the process of developing a web-based training initiative to improve its On-line Training efforts. This approach will provide employees with access to multi-media training materials (e.g., documentation, video and audio clips, graphics, drawings, links) through the company's web site, thereby combining the written instructions with the show-and-do techniques.

Howmedica Osteonics is in the process of developing a web-based training initiative to improve its On-line Training efforts. Each employee in the company must learn two new skill blocks each year to be eligible for the yearly raise under the Skill Based Pay Program. The current training methods make use of written work instructions that detail an operating procedure and hands-on training, where the novice is shown the proper operating techniques and the instructor observes the trainee performing the operation.

On-line Training will provide employees with access to multi-media training materials (e.g., documentation, video and audio clips, graphics, drawings, links) through the company's web site. The multi-media training materials combine the written instructions with the show-and-do techniques. The web site will also showcase the various teams and manufacturing processes. The employee can have access to blueprints, work instructions, video procedures, and helpful tips from any location that has Internet access. Multiple employees can use the materials at the same time. The creation and updating of the training materials will also be easier and faster. The processes will be documented more completely due to the ease of use. Machine downtime for training as well as time required from an experienced operator will both be reduced. The On-line Training web site will track employee training hours and career development, and collect feedback via on-line tests and question-and-answer sessions.

When the On-line Training system is fully implemented, the development, delivery, and tracking of training will be easier. Howmedica Osteonics anticipates the first machine will be on-line with the system around November 2000.

Appendix A
Table of Acronyms

No acronyms were used in this report.

Appendix B
BMP Survey Team

Team Member	Activity	Function
Larry Robertson (812) 854-5336	**Crane Division** Naval Surface Warfare Center Crane, IN	**Team Chairman**
Cheri Spencer (301) 403-8100	**BMP Center of Excellence** College Park, MD	**Technical Writer**
	Technology, Design, & Test Team	
Sam McSpadden (301)574-5444	**Oak Ridge National Library** Oak Ridge, TN	**Team Leader**
Thomas Clark (815)654-5515	**BMP Satellite Center** Rockford, IL	
	Logistics & Management Team	
Larry Halbig (317)891-9901	**BMP Field office** Indianapolis, IN	**Team Leader**
Allen Kimball (909)273-5116	**Naval Warfare Assessment Station** Corona, CA	

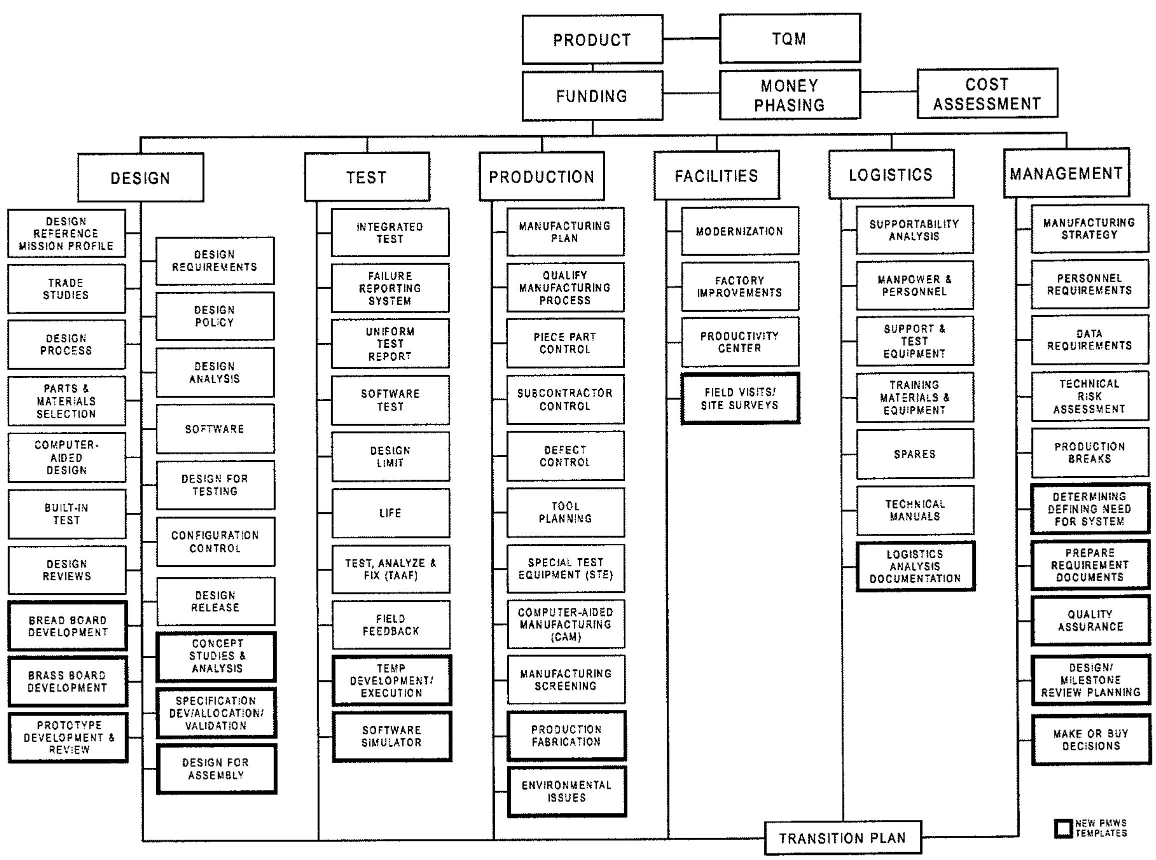
Appendix C

Critical Path Templates and BMP Templates

This survey was structured around and concentrated on the functional areas of design, test, production, facilities, logistics, and management as presented in the Department of Defense 4245.7-M, *Transition from Development to Production* document. This publication defines the proper tools—or templates—that constitute the critical path for a successful material acquisition program. It describes techniques for improving the acquisition process by addressing it as an *industrial* process that focuses on the product's design, test, and production phases which are interrelated and interdependent disciplines.

The BMP program has continued to build on this knowledge base by developing 17 new templates that complement the existing DOD 4245.7-M templates. These BMP templates address new or emerging technologies and processes.

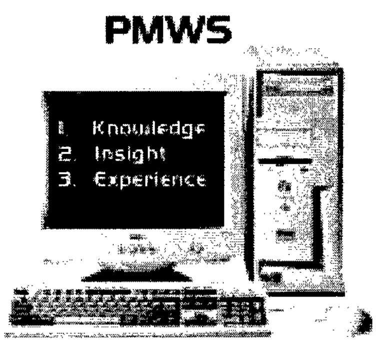
"CRITICAL PATH TEMPLATES FOR TRANSITION FROM DEVELOPMENT TO PRODUCTION"



Appendix D
The Program Manager's WorkStation

The Program Manager's WorkStation (**PMWS**) is an electronic suite of tools designed to provide timely acquisition and engineering information to the user. The main components of PMWS are KnowHow; the Technical Risk Identification and Mitigation System (TRIMS); and the BMP Database. These tools complement one another and provide users with the *knowledge*, *insight*, and *experience* to make informed decisions through all phases of product development, production, and beyond.

KnowHow provides knowledge as an electronic library of technical reference handbooks, guidelines, and acquisition publications which covers a variety of engineering topics including the DOD 5000 series. The electronic collection consists of expert systems and simple digital books. In expert systems, KnowHow prompts the user to answer a series of questions to determine where the user is within a program's development. Recommendations are provided based on the book being used. In simple digital books, KnowHow leads the user through the process via an electronic table of contents to determine which books in the library will be the most helpful. The program also features a fuzzy logic text search capability so users can locate specific information by typing in keywords. KnowHow can reduce document search times by up to 95%.



TRIMS provides insight as a knowledge-based tool that measures technical risk management rather than cost and schedule. Cost and schedule overruns are downstream indicators of technical problems. Programs generally have had process problems long before the technical problem is identified. To avoid this progression, TRIMS operates as a process-oriented tool based on a solid Systems Engineering approach. Process analysis and monitoring provide the earliest possible indication of potential problems. Early identification provides the time necessary to apply corrective actions, thereby preventing problems and mitigating their impact. TRIMS is extremely user-friendly and tailorable. This tool identifies areas of risk; tracks program goals and responsibilities; and can generate a variety of reports to meet the user's needs.

The **BMP Database** provides experience as a unique, one-of-a-kind resource. This database contains more than 2,500 best practices that have been verified and documented by an independent team of experts during BMP surveys. BMP publishes its findings in survey reports and provides the user with basic background, process descriptions, metrics and lessons learned, and a Point of Contact for further information. The BMP Database features a searching capability so users can locate specific topics by typing in keywords. Users can either view the results on screen or print them as individual abstracts, a single report, or a series of reports. The database can also be downloaded, run on-line, or purchased on CD-ROM from the BMP Center of Excellence. The BMP Database continues to grow as new surveys are completed. Additionally, the database is reviewed every other year by a BMP core team of experts to ensure the information remains current.

For additional information on PMWS, please contact the Help Desk at (301) 403-8179, or visit the BMP web site at http://www.bmpcoe.org.

Appendix E
Best Manufacturing Practices Satellite Centers

There are currently nine Best Manufacturing Practices (BMP) satellite centers that provide representation for and awareness of the BMP program to regional industry, government and academic institutions. The centers also promote the use of BMP with regional Manufacturing Technology Centers. Regional manufacturers can take advantage of the BMP satellite centers to help resolve problems, as the centers host informative, one-day regional workshops that focus on specific technical issues.

Center representatives also conduct BMP lectures at regional colleges and universities; maintain lists of experts who are potential survey team members; provide team member training; and train regional personnel in the use of BMP resources.

The nine BMP satellite centers include:

<u>**California**</u>

Chris Matzke
BMP Satellite Center Manager
Naval Warfare Assessment Division
Code QA-21, P.O. Box 5000
Corona, CA 91718-5000
(909) 273-4992
FAX: (909) 273-4123
matzkecj@corona.navy.mil

<u>**District of Columbia**</u>

Chris Weller
BMP Satellite Center Manager
U.S. Department of Commerce
14th Street & Constitution Avenue, NW
Room 3876 BXA
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(202) 482-8236/3795
FAX: (202) 482-5650
cweller@bxa.doc.gov

<u>**Illinois**</u>

Thomas Clark
BMP Satellite Center Manager
Rock Valley College
3301 North Mulford Road
Rockford, IL 61114
(815) 654-5515
FAX: (815) 654-4459
adme3tc@rvc.cc.il.us

<u>**Iowa**</u>

Bruce Coney
Program Manager
Iowa Procurement Outreach Center
2273 Howe Hall, Suite 2617
Ames, IA 50011
(515) 294-4461
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<u>**Louisiana**</u>

Al Knecht
Director
Maritime Environmental Resources & Information Center
Gulf Coast Region Maritime Technology Center
University of New Orleans
810 Engineering Building
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(504) 626-8918 / (504) 280-6271
FAX: (504) 727-4121
atk@neosoft.com

<u>**Michigan**</u>

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SAE/BMP Satellite Center Manager
755 W. Big Beaver Road, Suite 1600
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1250 Arthur E. Adams Drive
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FAX: (614) 688-5001
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(717) 843-5054, ext. 225
FAX: (717) 854-0087
snyderss@mantec.org

Tennessee

Tammy Graham
BMP Satellite Center Manager
Lockheed Martin Energy Systems
P.O. Box 2009, Bldg. 9737
M/S 8091
Oak Ridge, TN 37831-8091
(865) 576-5532
FAX: (865) 574-2000
grahamtb@ornl.gov

Appendix F
Navy Manufacturing Technology Centers of Excellence

The Navy Manufacturing Sciences and Technology Program established the following Centers of Excellence (COEs) to provide focal points for the development and technology transfer of new manufacturing processes and equipment in a cooperative environment with industry, academia, and Navy centers and laboratories. These COEs are consortium-structured for industry, academia, and government involvement in developing and implementing technologies. Each COE has a designated point of contact listed below with the individual COE information.

Best Manufacturing Practices Center of Excellence

The Best Manufacturing Practices Center of Excellence (BMPCOE) provides a national resource to identify and promote exemplary manufacturing and business practices and to disseminate this information to the U.S. Industrial Base. The BMPCOE was established by the Navy's BMP Program, The Department of Commerce, and the University of Maryland at College Park, Maryland. The BMPCOE improves the use of existing technology, promotes the introduction of improved technologies, and provides non-competitive means to address common problems, and has become a significant factor in countering foreign competition.

Point of Contact:
Anne Marie T. SuPrise, Ph.D.
Best Manufacturing Practices Center of Excellence
4321 Hartwick Road
Suite 400
College Park, MD 20740
(301) 403-8100
FAX: (301) 403-8180
annemari@bmpcoe.org

Center of Excellence for Composites Manufacturing Technology

The Center of Excellence for Composites Manufacturing Technology (CECMT) provides a national resource for the development and dissemination of composites manufacturing technology to defense contractors and subcontractors. The CECMT is managed by the Great Lakes Composites Consortium and represents a collaborative effort among industry, academia, and government to develop, evaluate, demonstrate, and test composites manufacturing technologies. The technical work is problem-driven to reflect current and future Navy needs in the composites industrial community.

Point of Contact:
Mr. James Ray
Center of Excellence for Composites Manufacturing Technology
c/o GLCC, Inc.
103 Trade Zone Drive
Suite 26C
West Columbia, SC 29170
(803) 822-3708
FAX: (803) 822-3710
jrglcc@glcc.org

Electronics Manufacturing Productivity Facility

The Electronics Manufacturing Productivity Facility (EMPF) identifies, develops, and transfers innovative electronics manufacturing processes to domestic firms in support of the manufacture of affordable military systems. The EMPF operates as a consortium comprised of industry, university, and government participants, led by the American Competitiveness Institute under a Cooperative Agreement with the Navy.

Point of Contact:
Mr. Alan Criswell
Electronics Manufacturing Productivity Facility
One International Plaza
Suite 600
Philadelphia, PA 19113
(610) 362-1200
FAX: (610) 362-1290
criswell@aci-corp.org

National Center for Excellence in Metalworking Technology

The National Center for Excellence in Metalworking Technology (NCEMT) provides a national center for the development, dissemination, and implementation of advanced technologies for metalworking products and processes. The NCEMT, operated by Concurrent Technologies Corporation, helps the Navy and defense contractors improve manufacturing productivity and part reliability through development, deployment, training, and education for advanced metalworking technologies.

Point of Contact:
Mr. Richard Henry
National Center for Excellence in Metalworking Technology
c/o Concurrent Technologies Corporation
100 CTC Drive
Johnstown, PA 15904-3374
(814) 269-2532
FAX: (814) 269-2501
henry@ctc.com

Navy Joining Center

The Navy Joining Center (NJC) is operated by the Edison Welding Institute and provides a national resource for the development of materials joining expertise and the deployment of emerging manufacturing technologies to Navy contractors, subcontractors, and other activities. The NJC works with the Navy to determine and evaluate joining technology requirements and conduct technology development and deployment projects to address these issues.

Point of Contact:
Mr. David P. Edmonds
Navy Joining Center
1250 Arthur E. Adams Drive
Columbus, OH 43221-3585
(614) 688-5096
FAX: (614) 688-5001
dave_edmonds@ewi.org

Energetics Manufacturing Technology Center

The Energetics Manufacturing Technology Center (EMTC) addresses unique manufacturing processes and problems of the energetics industrial base to ensure the availability of affordable, quality, and safe energetics. The focus of the EMTC is on process technology with a goal of reducing manufacturing costs while improving product quality and reliability. The EMTC also maintains a goal of development and implementation of environmentally benign energetics manufacturing processes.

Point of Contact:
Mr. John Brough
Energetics Manufacturing Technology Center
Indian Head Division
Naval Surface Warfare Center
101 Strauss Avenue
Building D326, Room 227
Indian Head, MD 20640-5035
(301) 744-4417
DSN: 354-4417
FAX: (301) 744-4187
mt@command.ih.navy.mil

Institute for Manufacturing and Sustainment Technologies

The Institute for Manufacturing and Sustainment Technologies (iMAST), was formerly known as Manufacturing Science and Advanced Materials Processing Institute. Located at the Pennsylvania State University's Applied Research Labortory, the primary objective of iMAST is to address challenges relative to Navy and Marine Corps weapon system platforms in the areas of mechnical drive transmission techologies, materials science technologies, high energy processing technologies, and repair technology.

Point of Contact:
Mr. Bob Cook
Institute for Manufacturing and Sustainment Technologies
ARL Penn State
P.O. Box 30
State College, PA 16804-0030
(814) 863-3880
FAX: (814) 863-1183
rbc5@psu.edu

Gulf Coast Region Maritime Technology Center

The Gulf Coast Region Maritime Technology Center (GCRMTC) is located at the University of New Orleans and focuses primarily on product developments in support of the U.S. shipbuilding industry. A sister site at Lamar University in Orange, Texas focuses on process improvements.

Point of Contact:
Dr. John Crisp, P.E.
Gulf Coast Region Maritime Technology Center
University of New Orleans
College of Engineering
Room EN-212
New Orleans, LA 70148
(504) 280-5586
FAX: (504) 280-3898
jncme@uno.edu

Appendix G
Completed Surveys

As of this publication, 122 surveys have been conducted and published by BMP at the companies listed below. Copies of older survey reports may be obtained through DTIC or by accessing the BMP web site. Requests for copies of recent survey reports or inquiries regarding BMP may be directed to:

Best Manufacturing Practices Program
4321 Hartwick Rd., Suite 400
College Park, MD 20740
Attn: Anne Marie T. SuPrise, Ph.D., Acting Director
Telephone: 1-800-789-4267
FAX: (301) 403-8180
annemari@bmpcoe.org

1985	Litton Guidance & Control Systems Division - Woodland Hills, CA
1986	Honeywell, Incorporated Undersea Systems Division - Hopkins, MN (now Alliant TechSystems, Inc.) Texas Instruments Defense Systems & Electronics Group - Lewisville, TX General Dynamics Pomona Division - Pomona, CA Harris Corporation Government Support Systems Division - Syosset, NY IBM Corporation Federal Systems Division - Owego, NY Control Data Corporation Government Systems Division - Minneapolis, MN
1987	Hughes Aircraft Company Radar Systems Group - Los Angeles, CA ITT Avionics Division - Clifton, NJ Rockwell International Corporation Collins Defense Communications - Cedar Rapids, IA UNISYS Computer Systems Division - St. Paul, MN
1988	Motorola Government Electronics Group - Scottsdale, AZ General Dynamics Fort Worth Division - Fort Worth, TX Texas Instruments Defense Systems & Electronics Group - Dallas, TX Hughes Aircraft Company Missile Systems Group - Tucson, AZ Bell Helicopter Textron, Inc. - Fort Worth, TX Litton Data Systems Division - Van Nuys, CA GTE C^3 Systems Sector - Needham Heights, MA
1989	McDonnell-Douglas Corporation McDonnell Aircraft Company - St. Louis, MO Northrop Corporation Aircraft Division - Hawthorne, CA Litton Applied Technology Division - San Jose, CA Litton Amecom Division - College Park, MD Standard Industries - LaMirada, CA Engineered Circuit Research, Incorporated - Milpitas, CA Teledyne Industries Incorporated Electronics Division - Newbury Park, CA Lockheed Aeronautical Systems Company - Marietta, GA Lockheed Missile Systems Division - Sunnyvale, CA (now Lockheed Martin Missiles and Space) Westinghouse Electronic Systems Group - Baltimore, MD (now Northrop Grumman Corporation) General Electric Naval & Drive Turbine Systems - Fitchburg, MA Rockwell Autonetics Electronics Systems - Anaheim, CA (now Boeing North American A&MSD) TRICOR Systems, Incorporated - Elgin, IL
1990	Hughes Aircraft Company Ground Systems Group - Fullerton, CA TRW Military Electronics and Avionics Division - San Diego, CA MechTronics of Arizona, Inc. - Phoenix, AZ Boeing Aerospace & Electronics - Corinth, TX Technology Matrix Consortium - Traverse City, MI Textron Lycoming - Stratford, CT

1991	*Resurvey of Litton Guidance & Control Systems Division* - Woodland Hills, CA Norden Systems, Inc. - Norwalk, CT (now Northrop Grumman Norden Systems) Naval Avionics Center - Indianapolis, IN United Electric Controls - Watertown, MA Kurt Manufacturing Co. - Minneapolis, MN MagneTek Defense Systems - Anaheim, CA (now Power Paragon, Inc.) Raytheon Missile Systems Division - Andover, MA AT&T Federal Systems Advanced Technologies and AT&T Bell Laboratories - Greensboro, NC and Whippany, NJ *Resurvey of Texas Instruments Defense Systems & Electronics Group* - Lewisville, TX
1992	Tandem Computers - Cupertino, CA Charleston Naval Shipyard - Charleston, SC Conax Florida Corporation - St. Petersburg, FL Texas Instruments Semiconductor Group Military Products - Midland, TX Hewlett-Packard Palo Alto Fabrication Center - Palo Alto, CA Watervliet U.S. Army Arsenal - Watervliet, NY Digital Equipment Company Enclosures Business - Westfield, MA and Maynard, MA Computing Devices International - Minneapolis, MN (now General Dynamics Information Systems) *(Resurvey of Control Data Corporation Government Systems Division)* Naval Aviation Depot Naval Air Station - Pensacola, FL
1993	NASA Marshall Space Flight Center - Huntsville, AL Naval Aviation Depot Naval Air Station - Jacksonville, FL Department of Energy Oak Ridge Facilities (Operated by Martin Marietta Energy Systems, Inc.) - Oak Ridge, TN McDonnell Douglas Aerospace - Huntington Beach, CA (now Boeing Space Systems) Crane Division Naval Surface Warfare Center - Crane, IN and Louisville, KY Philadelphia Naval Shipyard - Philadelphia, PA R. J. Reynolds Tobacco Company - Winston-Salem, NC Crystal Gateway Marriott Hotel - Arlington, VA Hamilton Standard Electronic Manufacturing Facility - Farmington, CT Alpha Industries, Inc. - Methuen, MA
1994	Harris Semiconductor - Palm Bay, FL (now Intersil Corporation) United Defense, L.P. Ground Systems Division - San Jose, CA Naval Undersea Warfare Center Division Keyport - Keyport, WA Mason & Hanger - Silas Mason Co., Inc. - Middletown, IA Kaiser Electronics - San Jose, CA U.S. Army Combat Systems Test Activity - Aberdeen, MD (now Aberdeen Test Center) Stafford County Public Schools - Stafford County, VA
1995	Sandia National Laboratories - Albuquerque, NM Rockwell Collins Avionics & Communications Division - Cedar Rapids, IA (now Rockwell Collins, Inc.) *(Resurvey of Rockwell International Corporation Collins Defense Communications)* Lockheed Martin Electronics & Missiles - Orlando, FL McDonnell Douglas Aerospace (St. Louis) - St. Louis, MO (now Boeing Aircraft and Missiles) *(Resurvey of McDonnell-Douglas Corporation McDonnell Aircraft Company)* Dayton Parts, Inc. - Harrisburg, PA Wainwright Industries - St. Peters, MO Lockheed Martin Tactical Aircraft Systems - Fort Worth, TX *(Resurvey of General Dynamics Fort Worth Division)* Lockheed Martin Government Electronic Systems - Moorestown, NJ Sacramento Manufacturing and Services Division - Sacramento, CA JLG Industries, Inc. - McConnellsburg, PA
1996	City of Chattanooga - Chattanooga, TN Mason & Hanger Corporation - Pantex Plant - Amarillo, TX Nascote Industries, Inc. - Nashville, IL Weirton Steel Corporation - Weirton, WV NASA Kennedy Space Center - Cape Canaveral, FL *Resurvey of Department of Energy, Oak Ridge Operations* - Oak Ridge, TN

1997	Headquarters, U.S. Army Industrial Operations Command - Rock Island, IL SAE International and Performance Review Institute - Warrendale, PA Polaroid Corporation - Waltham, MA Cincinnati Milacron, Inc. - Cincinnati, OH Lawrence Livermore National Laboratory - Livermore, CA Sharretts Plating Company, Inc. - Emigsville, PA Thermacore, Inc. - Lancaster, PA Rock Island Arsenal - Rock Island, IL Northrop Grumman Corporation - El Segundo, CA *(Resurvey of Northrop Corporation Aircraft Division)* Letterkenny Army Depot - Chambersburg, PA Elizabethtown College - Elizabethtown, PA Tooele Army Depot - Tooele, UT
1998	United Electric Controls - Watertown, MA Strite Industries Limited - Cambridge, Ontario, Canada Northrop Grumman Corporation - El Segundo, CA Corpus Christi Army Depot - Corpus Christi, TX Anniston Army Depot - Anniston, AL Naval Air Warfare Center, Lakehurst - Lakehurst, NJ Sierra Army Depot - Herlong, CA ITT Industries Aerospace/Communications Division - Fort Wayne, IN Raytheon Missile Systems Company - Tucson, AZ Naval Aviation Depot North Island - San Diego, CA *U.S.S. Carl Vinson* (CVN-70) - Commander Naval Air Force, U.S. Pacific Fleet Tobyhanna Army Depot - Tobyhanna, PA
1999	Wilton Armetale - Mount Joy, PA Applied Research Laboratory, Pennsylvania State University - State College, PA Electric Boat Corporation, Quonset Point Facility - North Kingstown, RI *Resurvey of NASA Marshall Space Flight Center* - Huntsville, AL Orenda Turbines, Division of Magellan Aerospace Corporation - Mississauga, Ontario, Canada
2000	Northrup Grumman, Defensive Systems Division - Rolling Meadows, IL Crane Army Ammunition Activity - Crane, IN Naval Sea Logistics Center, Detachment Portsmouth - Portsmouth, NH Stryker Howmedica Osteonics - Allendale, NJ

INTERNET DOCUMENT INFORMATION FORM

A . Report Title: Best Manufacturing Practices: Report of Survey Conducted at Stryker Howmedica Osteonics, Allendale, NJ

B. DATE Report Downloaded From the Internet: 01/14/02

C. Report's Point of Contact: (Name, Organization, Address, Office Symbol, & Ph #): Best Manufacturing Practices
Center of Excellence
College Park, MD

D. Currently Applicable Classification Level: Unclassified

E. Distribution Statement A: Approved for Public Release

F. The foregoing information was compiled and provided by:
DTIC-OCA, Initials: __VM__ **Preparation Date 01/14/02**

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